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BOTANY.—*Plant life on saline soils.*[1] THOMAS H. KEARNEY, Bureau of Plant Industry.

The topic that I have chosen for consideration this evening may not, at first thought, seem a very inviting one. Those of you who are familiar with salt marsh vegetation along the sea-coast and with the plant life of so-called "alkali" soils in the arid part of the country must have been impressed with their monotonous and rather unprepossessing aspects. Even the mangroves of tropical and subtropical shores, the most highly developed type of salt plants or halophytes, while intensely interesting from a biological point of view, are by no means so attractive to the casual eye as are many other forms of tropical plant life.

Nevertheless the halophytes have long been a subject of the greatest interest to botanists. Study of this vegetation in relation to its environment leads us into some of the most intricate problems in plant physiology.

ORIGIN AND NATURE OF THE SALINE COMPONENTS

Soils containing an excessive quantity of readily soluble salts are for the most part confined either to the immediate neighborhood of the ocean or to arid interior regions. In the former case the salinity of the soil is caused by periodical inundation

[1] Address of the retiring president of the Botanical Society of Washington delivered February 5, 1918.

with normal or dilute sea-water and the salts present are such as occur in the ocean.

In arid regions away from the coast, the accumulation of salts is due to local erosion. Owing to the scantiness of the rainfall, the saline components of the country rocks are not, as in humid regions, carried away by rivers flowing into the ocean. Instead they are transported short distances by the surface and underground drainage channels and become accumulated in the bottoms of the valleys and of closed basins. In this way are formed the salt lakes and the alkali flats, covered during the dry season with a glistening white crust of salts, which are so characteristic a feature of arid countries the world over.

Sea-water is practically uniform in the nature and proportion of its different salts and the same is necessarily true of the soil of coastal marshes. In both cases, sodium chloride strongly predominates. On the other hand, the saline components of soils in arid regions vary with the composition of the rocks from which they were derived. Salts of sodium (chloride, sulphate, carbonate, bicarbonate) are usually the most abundant, but the corresponding salts of potassium, magnesium, and calcium are commonly also present.

Since each salt, when presented in a pure solution, has its specific toxicity for plants, it might be thought that corresponding differences would be observed in the vegetation of "alkali" soils of different chemical composition. But there is little evidence that such is the case. The reason doubtless is that the solution in saline soils, like the water of the sea, is a "balanced" solution, in the sense of Loeb and Osterhout.[2] It rarely happens, in arid regions, that soluble salts occur in large quantity where the soil is deficient in calcium; and the presence of calcium equalizes, in large measure, the different toxicities shown in pure solutions by salts of the other bases.[3] Consequently, it is usu-

[2] W. J. V. Osterhout. *On the importance of physiologically balanced solutions for plants.* Bot. Gaz. **42**: 127. 1906; also **44**: 259. 1907. The same investigator has developed the subject in numerous subsequent papers.

[3] T. H. Kearney and F. K. Cameron. *Some mutual relations between alkali soils and vegetation.* U. S. Dept. Agr. Rept. **71**: 7–60. 1902. T. H. Kearney and L. L. Harter. *The comparative tolerance of various plants for the salts common in alkali soils.* U. S. Dept. Agr. Bur. Plant Ind. Bull. 113. 1907.

ally not so much the chemical composition of the soil solution as its concentration and the resulting osmotic pressure which affect vegetation.[4]

CONCENTRATION OF THE SOIL SOLUTION

Saline soils are extremely diverse in respect to texture, water-holding capacity, humus content, and fertility. The one thing that they have in common is a high concentration of the soil solution. This factor, also, is extremely variable, since not only the absolute quantity of salts may differ enormously within very short distances, but the concentration of the solution fluctuates continually, being diluted by rainfall or by inundation and concentrated by evaporation.

The fluctuations are greatest, of course, in deserts, where rainfalls of brief duration alternate with long periods of extreme drought. A salt content amounting to 3 per cent of the dry weight of the soil, to the depth penetrated by the plant roots, is not uncommon in arid regions. With this salt content, and with a water-holding capacity of 50 per cent, the soil, even when saturated with water, would have a solution concentration of 6 per cent, or twice that of sea-water. If the soil dried out to the wilting point for plants,[5] the concentration would reach 30 per cent, which is beyond the point of saturation for sodium chloride.

Even in humid climates the periodical fluctuations are by no means negligible. Hill[6] reported that in a salt marsh in Brittany, heavy rains lasting two days reduced the concentration of the soil solution to one-sixth of what was observed immediately before the rain began. If the original concentration had been that of sea-water, this would correspond to a fall in osmotic pressure of from about 22 to about 3.5 atmospheres.[7]

[4] This does not hold in the case of sodium carbonate ("black alkali") which, because of its strong alkalinity, is much more toxic than other salts of sodium.

[5] L. J. Briggs and H. L. Shantz. *The wilting coefficient for different plants and its indirect determination.* U. S. Dept. Agr. Bur. Plant Ind. Bull. 230. 1912.

[6] T. G. Hill. *The Bouche d'Erquy in 1908.* New Phytol. **8**: 97. 1909.

[7] Careful computations of the osmotic pressure of sea water have recently been published by R. H. True (*Osmotic experiments with marine algae.* Bot. Gaz. **65**: 71. 1918).

AGRICULTURAL IMPORTANCE OF SALINE SOILS

Saline soils are of small agricultural value until the excess salt has been removed by drainage and by flooding with fresh water. Extensive and successful reclamation work along these lines has been accomplished in India and in Egypt. Ganong[8] has described the methods by which the salt marshes at the head of the Bay of Fundy have been converted into hay meadows worth from $100 to $200 per acre.

Different crop plants differ in their adaptability to saline soils and a few of them are so resistant to concentrated solutions that they may be regarded as partial halophytes. First and foremost is the sugar beet, the supposed ancestor of which is a plant of the sea strand in Europe and northern Africa. Asparagus is another example, since the nearest related wild forms are said to inhabit saline soils and the cultivated form finds itself quite at home when it strays to the borders of salt marshes. Among fruit trees the date palm and the pomegranate are notable for their ability to thrive where the soil solution is highly concentrated.

From an agricultural point of view, however, the resistance of the plant is of less importance than the quantity and quality of the product for which it is grown. Cereals will make a fairly vigorous growth in soils where grain production is practically inhibited. The value of the beet for sugar making is much impaired, in saline soils, by the high ash content of the roots. Date palms, in spite of their vegetative vigor under such conditions, produce fruit of inferior value. Forage plants that are grown for the sake of the leaves and stems are usually, therefore, the most profitable crops for soils of relatively high salinity.

DISTRIBUTION OF THE VEGETATION

The principal types of halophytic vegetation may be roughly classified as:

1. Marine formations, consisting of aquatic plants, chiefly algae, which live in the ocean and in brackish water.

[8] W. F. GANONG. *The vegetation of the Bay of Fundy salt and diked marshes.* Bot. Gaz. 36: 161, 280, 349, 429. 1903.

2. Salt marsh, composed mainly of grasses, rushes, and sedges, with various other annua' and perennial herbs as a secondary element. Salt marsh vegetation is found chiefly in temperate regions, where it occurs both on the sea-coast and in very wet saline areas of the interior.

3. Salt scrub, composed of woody species, in large part Chenopodiaceae, ranging in size from half shrubs to almost tree-like dimensions. This formation is typically developed only where the climate is arid and the soil is not constantly wet.

4. The mangrove formation, of small trees belonging to the Rhizophoraceae and a few other families. This vegetation occupies muddy shores within reach of the tides, in and near the tropics.

Time permits only brief reference to the fascinating problem of the local distribution of halophytes. The vegetation of saline soils, both along the sea-coast and in the interior, often shows beautiful examples of zonation, determined, in large part, by differences in salinity, although the physical properties and the water content of the soil are likewise important factors.

The correlations between distribution of the plants and salt content of the soils are often so close as to permit of agricultural classification of the land on this basis, as has been demonstrated by Hilgard[9] and his colleagues in California and by Briggs, Shantz and the writer[10] in the vicinity of Great Salt Lake. The different types of halophytic vegetation were found to indicate with considerable precision the degree of salinity of the soil and hence whether the land is suitable for crop production or could be rendered suitable by the usual methods of reclamation. The indicator plant method is particularly useful in dry areas where there may be no superficial evidence of salinity but where large quantities of salt may be present in the subsoil.

The importance of halophytes as geological agents deserves

[9] E. W. Hilgard. Soils, pp. 534–549. New York, 1906.

[10] T. H. Kearney, L. J. Briggs, H. L. Shantz, J. W. McLane, and R. L. Piemeisel. *Indicator significance of vegetation in Tooele Valley, Utah.* Journ. Agr. Research 1: 365–417. 1914.

mention. Oliver[11] and other British ecologists have investigated the manner in which Spartina, Salicornia, etc., colonize and hold newly-deposited soil on the sea-coast. Vaughan[12] gives an interesting account of land-building by the mangrove in southern Florida.

Halophytic vegetation is characterized by world-wide uniformity. Each of the principal types—salt marsh, salt scrub, and the mangrove formation—has much the same appearance, wherever it occurs. The comparatively small number of species, the similarity of the life forms, and the scarcity of showy flowers give a monotonous and even somber appearance to these plant formations.

In taxonomic composition, likewise, there is comparatively little variation within each of the major halophytic formations, in different parts of the world. The genera, and in many cases even the species, are very widely distributed. The great majority of extreme halophytes are comprised in comparatively few families. Probably not less than one-half of the species belong to the Chenopodiaceae, which comes nearer to being a purely halophytic group than any other of the larger families of plants. Smaller families which are predominantly halophytic are Plumbaginaceae, Frankeniaceae, Tamaricaceae, and Rhizophoraceae. Families which, although not primarily halophytic, contribute numerous genera and species to this vegetation are Gramineae, Cruciferae, and Compositae. Other large groups are conspicuous for their absence from saline soils. Among these are the lichens, mosses, ferns, Araceae, Orchidaceae, Fagaceae, and Ericaceae.

STRUCTURE OF HALOPHYTES

As a rule, the leaf surface of halophytes is much reduced as compared with that of mesophytes. In Salicornia and allied

[11] F. W. Oliver. *The shingle beach as a plant habitat.* New Phytol. **11**: 73. 1912. *Some remarks on Blakeney Point, Norfolk.* Journ. Ecol. **1**: 4. 1913. *Vegetation and mobile ground as illustrated by* Suaeda fruticosa *on shingle.* Journ. Ecol. **1**: 249. 1913.

[12] T. W. Vaughan. *The geologic work of mangroves in southern Florida.* Smiths. Misc. Coll. **5**: 461. 1910.

genera of Chenopodiaceae and in the tamarisks, the assimilating tissue is located mainly in the stems, the leaves being mere scale-like vestiges. The mangroves are a striking exception, possessing a heavy crown of broad leaves.

Thickness of the leaves and stems characterizes most halophytes, aside from the grasses and grass-like plants. LeSage[13] compared numerous maritime species with the most nearly related inland forms and found that in the great majority of cases the former had the thicker leaves. In some species the thickening results merely from an increase in size of cells or in number of layers of the chlorophyll tissue, but many halophytes possess also a specialized water storage tissue of thin-walled cells, containing few or no chloroplasts.

The degree of succulence is closely associated with the salinity of the medium. Several investigators have reported that non-halophytic species, when watered with salt solutions, show an increase in the thickness of the leaf. Conversely, halophytes, when grown in an ordinary garden soil with fresh water irrigation, often develop thinner leaves and stems than in their natural habitat. Batalin[14] found that even Salicornia responded in this manner. Holtermann[15] obtained a marked increase in the thickness of the water storage tissue of mangroves by watering the plants with a sodium chloride solution of about twice the concentration of sea-water. On the other hand, irrigation with fresh water resulted in the development of much thinner leaves than were observed in the normal habitat.

Casu[16] has pointed out that succulent halophytes occur in nature only where the soil has a high water content as well as a high salt content. It is otherwise with the succulent xerophytes, such as Cactaceae, which prefer soils that are normally

[13] P. LESAGE. *Recherches expérimentales sur les modifications des feuilles chez les plantes maritimes.* Rev. Gén. Bot. **2**: 54, 106, 163. 1890.

[14] A. BATALIN. *Die Wirkung des Chlornatriums auf die Entwickelung von* Salicornia herbacea. Bull. Congr. Internat. Bot. Hort., 1884, p. 219. St. Pétersb. 1885.

[15] C. HOLTERMANN. *Der Einfluss des Klimas auf den Bau der Pflanzengewebe.* Berlin, 1907.

[16] A. CASU. *Contribuzione allo studio della flora delle saline di Cagliari.* Ann. di Bot. **2**: 403. 1905.

dry, as well as non-saline. Since the Cactaceae, as Cavara[17] and Livingston[18] have shown, are also characterized by a low osmotic pressure of the cell sap, while the succulent halophytes develop very high pressures, it is evident that the relation between succulence and salinity is by no means a simple problem.

Schimper and other ecologists regarded halophytes as being xerophytes, or drought resistant plants, in that their structure is modified so as to reduce transpiration. Later investigators have shown the one-sidedness of this point of view. It originated largely in the mistaken conception that plants of the sea beaches and dunes, many of which have a markedly xerophytic structure, are really halophytes.[19] It is true that in arid climates many, but by no means all, salt plants exhibit xerophytic peculiarities, such as reduced leaf surface, sunken stomata, thick cuticle, highly developed palisade tissue, and small intercellular spaces. On the other hand, certain xerophytic characters, particularly hairiness and the excretion of resin and of aromatic volatile oils, are rarely met with in halophytes, even in those that inhabit deserts.[20]

In cool, humid regions, some of the most characteristic salt marsh plants exhibit almost no xerophytic peculiarities, having a thin cuticle, stomata level with the epidermis or even slightly raised, and large intercellular spaces. Terras[21] in Scotland and Cross[22] in New Zealand studied the anatomy of coastal halophytes and concluded that some of them have the structure of aquatic plants rather than of desert plants.

[17] F. Cavara. *Risultati di una serie di ricerche crioscopiche sui vegetali.* Contrib. Biol. Veg. (Palermo) **4**: 41. 1905.

[18] B. E. Livingston. *The relation of desert plants to soil moisture and to evaporation.* Carnegie Inst. Publ. 50. 1906.

[19] T. H. Kearney. *Are plants of beaches and dunes true halophytes?* Bot. Gaz. **37**: 424. 1904.

[20] Detailed descriptions of the anatomy of many European halophytic species and an extensive bibliography are given by H. Chermezon (*Recherches anatomiques sur les plantes littorales.* Ann. Sci. Nat. IX. Bot. **12**: 117–313, *figs. 1–52.* 1910).

[21] J. A. Terras. *Notes on the salinity of the cell sap of halophytes.* Proc. Scottish Micr. Soc. **4**: 152. 1906.

[22] B. D. Cross. *Some New Zealand halophytes.* Trans. New Zealand Inst. **42**: 545. 1910.

The gist of the matter is that many halophytes that grow under climatic conditions favorable to intense transpiration, or in soils subject to periodical drought, show xerophytic modifications; but high concentration of the soil solution does not necessarily induce this type of structure if the climate is humid and an abundance of soil moisture is normally present.

WATER ECONOMY OF HALOPHYTES

It has been repeatedly demonstrated that absorption of water by the roots of nonhalophytic species is difficult or impossible when the soil solution reaches such concentrations as are encountered in the natural habitats of halophytes. When forced to obtain their water from a relatively concentrated salt solution, ordinary mesophytes, such as the common crop plants, show a marked decrease in transpiration and in photosynthetic activity, resulting in diminished growth.

Schimper[23] argued from the known behavior of nonhalophytes when exposed to strong salt solutions, and from the assumed xerophytic structure of all halophytes, that the latter are subject to the danger of injury from excessive accumulations of salt in their assimilating cells, and that protection against this danger is secured by reduction of the transpiration. He later[24] modified this view by attributing the supposed necessity for reduced transpiration to the difficulty of absorption by the roots from a strong salt solution. In his view a saline soil is "physiologically dry," even when saturated with water.

More recent investigations have demolished all of the premises upon which this theory rested. It has already been pointed out that by no means all salt plants possess a transpiration-reducing structure, so that we are justified in speaking of halophilous mesophytes and hydrophytes, as well as of halophilous xerophytes. Species that inhabit dry saline soils in arid regions doubtless find advantage in such structural modifications as tend to diminish transpiration; but the researches of

[23] A. F. W. SCHIMPER. Die indo-malayische Strandflora, p. 26. Jena, 1891.

[24] A. F. W. SCHIMPER. Pflanzengeographie auf physiologischer Grundlage, p. 100. Jena, 1898.

Rosenberg[25] and Delf[26] on salt marsh plants in northern Europe and Von Faber's[27] investigations of mangroves in the East Indies have shown that many halophytes transpire freely when growing in their normal habitats.[28]

In conformity with these results as to transpiration, Ganong[29] and Hill[30] have proven that high osmotic pressures are developed in the roots of halophytes. Difficult absorption of water cannot, therefore, be a universal condition of existence for this type of vegetation.

The salt plants are evidently able to carry on normally the processes of photosynthesis, metabolism, and growth, notwithstanding the presence of much salt in their cell sap This is sufficient proof that they are not inconvenienced by the high osmotic pressures in their cells nor by the specific toxicity of the salt. It is clearly not permissible to draw conclusions as to the normal physiology of halophytes from the pathological conditions induced in nonhalophytes by exposure to concentrated salt solutions.

Our knowledge of the physiology of halophytes is one-sided, since it has been gained chiefly by the study of salt marsh plants in northern Europe and of the mangrove formation in the tropics. Neither of these environments affords such extreme conditions as must be endured by plants inhabiting saline soils in desert regions. Here the atmospheric conditions are conducive to excessive transpiration, while enormous fluctuations in the water content of the soil and in the concentration of the soil solution

[25] O. ROSENBERG. *Ueber die Transpiration der Halophyten.* Kongl. Vetensk. Akad. Förhandl. 531. 1897.

[26] E. M. DELF. *Transpiration and the behavior of stomata in halophytes.* Annals of Botany **25**: 485. 1911.

[27] F. C. VON FABER. *Ueber Transpiration und osmotischen Druck bei den Mangroven.* Ber. Deutsch. Bot. Ges. **31**: 277. 1913.

[28] It has been ascertained by HOLTERMANN and by RUHLAND, however, that in halophytes grown in strongly saline soils and having a high concentration of the cell sap, the quantity of water transpired is smaller than when the same species are grown in the absence of an excessive quantity of salt.

[29] Bot. Gaz. **36**: 358–362. 1903.

[30] T. G. HILL. *Observations on the osmotic pressures of the root hairs of certain salt marsh plants.* New Phytol. **7**: 133. 1908.

require corresponding powers of accommodation in the absorbing organs of the plant. A thorough investigation of the water economy of desert halophytes is, therefore, much to be desired

OSMOTIC PRESSURE IN ROOTS AND LEAVES

Comparatively few determinations have been made of the osmotic pressures in the roots of halophytes. The data at hand indicate that, at least under the comparatively favorable conditions of coastal salt marshes, the plant is easily able to cope with the problem of absorption. Thus Hill found that the root hairs of Salicornia can develop a pressure corresponding to that of an 8.7 per cent solution of sodium chloride, which is probably equivalent to about 65 atmospheres.

As regards halophytes that inhabit arid regions, determinations appear to have been made only on the leaves and stems. In ordinary mesophytic plants of temperate climates the osmotic pressure of the leaf cells seldom exceeds 30 atmospheres and is usually much lower than this. But pressures up to 100 atmospheres were detected in the leaves and stems of salt plants by Cavara in Italy and by Fitting[31] in the Sahara Desert. Ruhland was able to develop, in the leaves of *Statice Gmelini*, a pressure which he estimated at 165 atmospheres.[32]

It is not improbable that the absorbing roots of desert halophytes cease temporarily to function when, as doubtless often happens, the osmotic pressure of the soil solution greatly exceeds 100 atmospheres. Miss Halket's[33] observation that when the salt content of the soil solution reached 17 per cent, plants of Salicornia remained alive and apparently uninjured but ceased to grow, points in this direction.

There is abundant evidence of the ability of halophytes to

[31] H. FITTING. *Die Wasserversorgung und die osmotischen Druckverhältnisse der Wüstenpflanzen.* Zeitschr. Bot. **3**: 209. 1911.

[32] It does not follow that equally high pressures would have been detected in the roots, since comparative determinations upon different organs of the same individual plant have shown, in numerous cases, that the osmotic pressures of the root cells are lower than those of the leaf cells.

[33] A. C. HALKETT. *The effect of salt on the growth of Salicornia.* Annals of Botany **29**: 143. 1915.

accommodate their osmotic pressure to fluctuations in that of the medium. Hill found this to be the case in the root hairs of Salicornia. Von Faber observed that the pressure in the leaf cells of mangroves varied with the salinity of the soil solution. Cavara found that in Italian salt marsh plants the pressures were from 2 to 3 times as high after a long dry period as during the rainy season. The enormous power of osmotic accommodation possessed by many bacteria, fungi, and algae is well known. Plants that inhabit the waters and shores of estuaries and tidal creeks, where daily fluctuations of great magnitude in the salinity of the medium occur, must possess the ability to alter their osmotic pressure rapidly.[34]

SALT CONTENT OF THE TISSUES

Various means are employed in developing these high pressures. In some cases the salt absorbed from the soil solution appears to be the principal factor, while in other cases organic compounds elaborated by the plant itself (carbohydrates, tannins) play the chief part. Fitting found that among species growing side by side in the Sahara Desert, and manifesting approximately the same resistance to plasmolysis, some had a highly saline cell sap, while in others there was no noteworthy accumulation of salt. He concluded that the maximum amount of salt that can be accumulated in the tissues is a character of the species, independent, in large measure, of transpiration and of the salt content of the soil.

Many halophytes take up sodium and chlorine in greater proportion than these occur in the soil solution. Such plants, even when grown on soils containing only traces of these elements, may accumulate large quantities in their tissues.[35]

Schimper[36] ascertained that certain weeds that are character-

[34] An interesting example of such accommodation is described by W. J. V. Osterhout (*The resistance of certain marine algae to changes in osmotic pressure*. Univ. Calif. Publ. **2**: 227. 1906).

[35] G. Paris found that the leaves of a species of Atriplex, when growing on a soil containing the merest trace of chlorides, had an ash content of 37 per cent and a chloride content of 10 per cent of the total dry weight (*Sul' Atriplex halimus L.* Staz. Sper. Agrar. Ital. **44**: 141. 1911).

[36] A. F. W. Schimper. Die indo-malayische Strandflora, p. 142. 1891.

istic of soils rich in nitrogen also possess this power of selective absorption. Individuals of these species were found to give a strong reaction for nitrates, even when growing on soils of low nitrogen content.

The quantity of water-soluble salts taken up by halophytes is often considerable. Cameron[37] found that in a sample of greasewood (Sarcobatus) salts of sodium constituted about 20 per cent of the total dry weight of the leaves. All of the sodium chloride present was apparently free in the cell-sap and could be recovered by leaching the dry material with water, as Déhérain[38] had previously ascertained to be the case with *Salsola Kali*. Paris, on the other hand, states that in *Atriplex Halimus*, the results of freezing-point determinations indicated that, of the total chlorine found in the ash, only about half was free in the cell sap.

In view of the injurious effects of concentrated solutions of sodium salts upon ordinary plants, the question arises, how are halophytes able to adjust themselves to such extreme salinity of their cell-sap? A strong development of water tissue, the cells of which contain few or no chloroplasts, is, as we have seen, characteristic of many salt plants. The plausible suggestion has been made that much of the salt taken up by such plants is stored in this tissue, rather than in the green assimilating cells, although apparently no direct evidence of such segregation has been obtained.

Many halophytic species are able to check the accumulation of salt in their tissues by excreting it, in solution, upon the surface of their leaves and stems. This phenomenon is not confined to plants that possess specialized excretory organs. In the case of grasses like Spartina and Distichlis excretion is supposed to take place through the stomata.[39]

The best known cases of salt excretion are found in the Plumbaginaceae, Frankeniaceae, and Tamaricaceae. The members of these families are characterized by the possession of

[37] F. K. Cameron. U. S. Dept. Agr. Rep. **71**: 64–66. 1902.

[38] P. Déhérain. *Sur l'assimilation des substances minérales par les plantes.* Ann. Sci. Nat. VI. Bot. **6**: 366. 1878.

[39] A. B. Klugh. *Excretion of sodium chloride by* Spartina glabra alterniflora. Rhodora **11**: 237. 1909.

epidermal glands, the cells of which are very rich in protoplasm and have a large nucleus. The process of excretion by these organs is not a passive filtration, but a true glandular activity, as has been demonstrated by the writer[40] and by Ruhland.[41] The latter investigator also obtained fairly conclusive evidence that the salt content of the leaves is materially reduced when excretion is actively taking place.

It would seem to be significant that as a rule the species which excrete salt do not possess a highly developed water-storage tissue. On the other hand, salt excretion is not known to occur in the Chenopodiaceae, the largest and most important of halophytic families. This family includes numerous genera in which water-storage tissue is exceptionally well developed.

PHYSIOLOGICAL CHARACTERISTICS OF SALT PLANTS

From what has been said, it is evident that there are many gaps and many apparent contradictions in our knowledge of the normal physiology of the salt plants. Two characteristics, however, are general and may be said to be conditioned by the nature of the environment. These are

1. Ability to develop a high osmotic pressure in the cells of the absorbing organs, thus allowing water to be taken up from solutions of a concentration which would inhibit absorption in nonhalophytic species. Coupled with this, is the power of accommodating the pressure to (often rapid) changes of concentration in the medium.

2. Ability to carry on normally all essential physiological functions, notwithstanding the presence of salt in the cell sap in quantities which, in nonhalophytic species, would seriously hamper or entirely prevent photosynthesis, metabolism, and growth.

IMPORTANCE OF SODIUM TO HALOPHYTES

The problem of whether halophytes can grow in the absence of an appreciable quantity of sodium salts has been the subject

[40] T. H. KEARNEY. *On the excretion of hygroscopic salts in Frankenia and Statice.* Science N. S. 19: 419. 1904.

[41] W. RUHLAND. *Die Salzdrüsen der Plumbaginaceen.* Jahrb. Wiss. Bot. 55: 409. 1915.

of numerous cultural experiments. The results are contradictory even, in some cases, when the same species was used by different experimenters. Unquestionably, certain species that in nature are confined to saline soils, will not only thrive but grow more vigorously in the absence of a noteworthy quantity of salt, although the appearance and structure of the plants may be materially altered.

Batalin claimed that even such an extreme halophyte as *Salicornia herbacea* can be grown successfully in ordinary garden soil, watered with river water. On the other hand, Peklo[42] found that this plant soon died in a Knop nutrient solution, which contains no sodium, but flourished in the same solution plus 2 per cent of sodium chloride. Similar results with other species of Salicornia were obtained by Miss Halket.

The published data on cultural experiments which indicate that sodium salts are important to halophytes, do not permit a conclusion to be drawn as to whether the limiting factor is the presence of the element sodium or merely a high total concentration in the medium. It would be interesting to know whether the results with Salicornia in water cultures would have been equally satisfactory, if the salt added in excess to the nutrient solution had been potassium chloride, instead of sodium chloride.

In order to determine definitely whether the salt plants can completely dispense with sodium, it would, of course, be necessary to insure the absence of any trace of the element, in both plant and culture medium. Since sodium is known to occur even in the seeds of halophytes, this experimental condition is probably impossible to realize.

SODIUM IN PLANT NUTRITION

Consideration of the physiology of halophytes brings up the question, what, if any, is the rôle of sodium in plant nutrition? Osterhout[43] states that this element, because of its protective or antagonistic action, is essential to the maintenance of life in

[42] J. Peklo. *Bemerkungen zur Ernährungsphysiologie einiger Halophyten.* Oesterr. Bot. Zeitschr. **62**: 47, 114, 172. 1912.

[43] W. J. V. Osterhout. *Plants which require sodium.* Bot. Gaz. **54**: 532. 1912.

certain marine algae; and results obtained by Benecke[44] indicate that some of the Cyanophyceae may grow equally well if potassium is completely replaced by sodium in the nutrient solution. In regard to the nutrition of vascular plants, however, no fact seems to be better established than the indispensability of a minimum of potassium. On the other hand, it has never been proven that sodium is indispensable to any of the higher forms of plant life.

Although sodium is almost always found in the ash of plants, it does not, as far as we know, enter into organic combination. This would seem to indicate that plant life is not conditioned by its presence as by the presence of potassium, phosphorus, and magnesium. Nevertheless, it by no means follows that under certain conditions sodium may not be an important factor in growth.

Different investigators of the fertilizer value of sodium salts report widely divergent results, but it is impossible to ignore the numerous instances in which beneficial effects have been observed, especially where the soil is deficient in potassium in readily available form.[45]

Such effects are doubtless, in many cases, due chiefly to the setting free by chemical reaction in the soil of the potassium of relatively insoluble compounds. But even when such reaction was excluded by growing the plants in water cultures or in quartz sand, without the addition of potassium, sodium has been observed to stimulate growth.

It would seem, therefore, that when potassium is not available in sufficient quantity, some of the physiological functions which are normally performed by that element may be assumed by sodium. In regard to the nature of these functions, the following suggestions have been made:

[44] W. BENECKE. *Ueber Culturbedingungen einiger Algen.* Bot. Zeitung 56: 84–96. 1898.

[45] This has been the subject of long-continued investigation by the Rhode Island Agricultural Experiment Station. The results have been published in the annual reports for 1894 to 1906 and in bulletins 47, 104, 106, and 153. See especially H. J. WHEELER and B. L. HARTWELL (*Concerning the functions of sodium salts.* R. I. Agr. Exp. Sta. Ann. Rep. 1906: 186–316. 1907).

1. Translocation, into and within the plant, of indispensable anions, such as nitrogen and phosphorus.

2. Maintenance in the cells of a requisite minimum osmotic pressure, upon which depends the turgor necessary for growth.

3. Antagonistic or protective action, in relation to other elements, by which a balanced solution is maintained.

4. Neutralization of organic acids formed within the plant.

5. Stimulation of diastatic activity in the cells.

In the present national emergency, current notions in regard to fertilizers should be subjected to the most rigorous criticism. A huge superstructure of opinion in regard to our potash requirements has been erected by the commercial fertilizer interests, domestic and foreign, upon an amazingly small basis of proven fact.

The enemy boasts that his control of the great potash deposits makes him the agricultural dictator of the world. Wilhelm Ostwald is quoted as having said that the United States "went into the war like a man with a rope around his neck, a rope which is in enemy hands." All the resources of an ably-directed propaganda have been employed for years in fostering among us the belief that we are helplessly dependent upon Germany in this matter. It would be folly, and worse than folly, to concede such a claim until we have thoroughly examined its foundations.

For certain soils and certain crops, the addition of potash in readily available form may well be essential to profitable production. But who knows whether the indispensable minimum is 250,000 tons or only one-tenth of that quantity? Cannot the apparent need be lessened by better tillage, by rotation with green manure crops, and by the more extensive use of farm manure? Will not the use of cheaper chemical fertilizers—salts of sodium, calcium, magnesium—alleviate many of the supposed cases of "potash hunger?" Until these questions have been answered, no one dare say that our absolute requirement of potash fertilizers cannot be met by the development of domestic sources of supply.

BOTANY.—*A new species of Rondeletia from Mexico.*[1] PAUL C. STANDLEY, National Museum.

In an interesting collection of plants received recently from Dr. B. P. Reko, of the State of Oaxaca, Mexico, by the U. S. National Museum, are specimens of a handsome rubiaceous plant referable to the genus *Rondeletia*. The plant offers so many characters not found in other species as to suggest a new generic type, but the species of *Rondeletia* already known show a remarkable range of variation for the family Rubiaceae, and the present plant is perhaps not more abnormal than some of the Cuban species, such as *R. tinifolia* Griseb. and *R. correifolia* Griseb.

Rondeletia Rekoi Standley, sp. nov.

Branchlets stout or slender, obtusely tetragonous, densely and persistently white-tomentose, with a close tomentum; stipules linear-oblong, 6 to 9 mm. long, bidentate at the apex, erect, persistent, densely tomentose outside on the lower half, glabrate and green above; leaves opposite, the petioles very stout, 0.5 to 1.5 cm. long, white-tomentose, the blades ovate or elliptic-ovate, 8.5 to 19 cm. long, 3 to 8.5 cm. wide, rounded and short-decurrent at the base, very acute or subacuminate at the apex, subchartaceous, bright-green above, lustrous, scabrous with short slender curved hairs, the intermediate veins very prominent, finely reticulate, beneath densely covered with a close white tomentum, the costa prominent, the lateral veins slender, about 14 on each side, subarcuate, the margin plane or subrevolute; inflorescence terminal (a pair of cymes present at the base of the peduncle), the peduncles stout, 8 to 9 cm. long, the rachis 6 to 9 cm. long, bearing numerous short-pedunculate bifid cymes, the branches of these 1.5 to 2.5 cm. long, the flowers sessile, secund, the bractlets oval or oblong, obtuse, green, glabrate, about equaling the calyx-tube; calyx-tube densely white-tomentose, the 4 lobes oblong or oval, about 1 mm. long, rounded at the apex, green, glabrate, spreading; corolla white-tomentose outside, the tube stout, 5.5 to 7 mm., long, glabrous in the throat, the 4 lobes rounded, 2 mm. long, undulate; anthers sessile, included; capsule 3.5 to 4 mm. broad, didymous-globose, densely white-tomentose; seeds minute, pale-brown, angulate.

Type in the U. S. National Herbarium, no. 867145, collected at Cafetal Las Pilas (Cerro Espino), Oaxaca, Mexico, altitude 400 meters, October 10, 1917, by Dr. B. P. Reko (no. 3490).

[1] Published by permission of the Secretary of the Smithsonian Institution.

It is difficult to determine the exact relationship of *Rondeletia Rekoi* among its Central American allies. The dense tomentum of the leaves is characteristic of many continental species, but the plan of the inflorescence is unlike that of any other *Rondeletia*. The cymes simulate perfectly those of the genus *Antirhea*, of the remotely related tribe *Guettardeae*, although in that group the cymes are solitary and axillary, rather than racemose, as in this plant. The stipules, too, of *R. Rekoi*, are different from those of any other species, and the prominent reticulation of the upper leaf-surface seems unique. The plant shows a strong color contrast between the bright green upper surfaces of the leaves and the white lower surfaces and stems, and would doubtless prove attractive in cultivation.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Ground water in San Simon Valley, Arizona and New Mexico.* A. T. SCHWENNESEN. U. S. Geological Survey Water-Supply Paper 425-A. Pp. 35, with maps. 1917.

This is a preliminary report on an extensive investigation of the Quaternary geology of the San Simon Valley and adjacent parts of Gila Valley and its relation to artesian water supplies in the region. The stream deposits, which resemble the ordinary deposits of other desert basins, are here separated by beds that were laid down in a lake or other body of water to a depth of several hundred feet. These lake beds form a gentle syncline whose axis nearly coincides with the axis of the valley. They include 300 to 400 feet of dense, homogeneous, blue clay, which serves well as a confining bed for the water in the underlying sand strata and older alluvium. Extrusive basalt is interbedded with the stream deposits and layers of tuff occur in the lacustrine formation.

The report gives data on artesian and pump wells, and on the decrease in artesian pressure. It includes an excellent discussion of agricultural possibilities by R. H. FORBES. O. E. MEINZER.

GEOLOGY.—*Ground water for irrigation in the Morgan Hill area, California.* W. O. CLARK. U. S. Geological Survey Water-Supply Paper 400-E. Pp. 48, with 3 plates. 1917.

The water-bearing formation in the area consists of recent alluvial deposits which are composed of clay or claylike materials, sand, and gravel. Most of the deposits were formed by Coyote River, which has built an alluvial fan entirely across the valley and which has alternately diverted the streams on it into the Bay of Monterey and into San Francisco Bay.

In this report an attempt is made to estimate the quantity of ground water available for irrigation within the area, based on the annual fluctuation of the water table and the porosity of the materials as shown by the logs of wells within the area. The results concerning porosity are checked against a pumping test made at the Lower Gorge by the Bay Cities Water Company in which records were kept of the quantity of water pumped, the area over which the water table was lowered as a result of pumping, and the amount of lowering. A further check is made by the use of stream-flow data, which show the amount of water lost by Coyote River through percolation during a four-year period, 1903 to 1907. W. O. C.

GEOLOGY.—*Tin resources of the Kings Mountain district, North Carolina and South Carolina.* ARTHUR KEITH and D. B. STERRETT. U. S. Geological Survey Bulletin 660-D. Pp. 24, with maps, sections, and illustrations. 1917.

The Kings Mountain district contains both metamorphic and igneous rocks, and the metamorphic rocks include some of sedimentary and some of igneous origin. In age the rocks range from Archean to Triassic. The formations that are associated with the tin deposits are the Carolina gneiss and a Roan gneiss, of Archean age; the Bessemer granite, of pre-Cambrian age; the Whiteside granite; and, especially, tin-bearing pegmatites of late Paleozoic age.

The pegmatite occurs in sheets, lenses, and irregular masses ranging in thickness from a few inches to many yards and attaining half a mile in length. The tin-bearing deposits occur in pegmatite masses within Archean rocks, either the Roan gneiss or the Carolina gneiss along or near its contact with the Roan gneiss. The cassiterite appears to have been one of the first minerals in the pegmatite to crystallize, and it seems clear that the cassiterite was an original constituent of the pegmatite. R. W. STONE.

GEOLOGY.—*Zinc carbonate and related copper carbonate ores at Ophir, Utah.* G. F. LOUGHLIN. U. S. Geological Survey Bulletin 690-A. Pp. 14, with illustrations. 1917.

This paper calls attention to the marked lamellar structure of the zinc carbonate, the prevailing absence of calamine, and the intimate association of the zinc carbonate with copper carbonates in the Ophir mining district. The processes of deposition of the carbonates are described and the following conclusions of economic importance are reached:

It is to be expected that bodies of lamellar zinc carbonate like those

at Ophir will prove to be of high grade, owing to the complete removal of limestone, but of small dimensions and confined to the immediate vicinity of fractures and open bedding planes. Such small bodies are not likely to lead to larger bodies of massive ore, unless they lie near to groundwater level, or to some impervious stratum or fault that impounded the waters containing the oxidized compounds of zinc.

Where mixed sulphide deposits in limestone contain both copper and zinc in considerable quantity the resulting carbonate ores of both metals are to be expected in the oxidized zone, the copper carbonate immediately below the position of the original sulphide body or its siliceous casing, and the zinc carbonate below the copper carbonate.

R. W. STONE.

ORNITHOLOGY.—*Notes on North American birds, II.* HARRY C. OBERHOLSER. The Auk **34**: 321–329. July, 1917.

The Arizona subspecies of *Vireo bellii*, originally characterized by Mr. Ridgway, and commonly regarded as inseparable from *Vireo bellii pusillus*, is shown to be different and is recognized as *Vireo bellii arizonae* Ridgway. The form of *Baeolophus inornatus* inhabiting the Pacific Coast region from northern Lower California, north through southern California to Santa Barbara County, and described by Mr. Ridgway as *Baeolophus inornatus murinus*, is also reinstated. Two races of *Baeolophus wollweberi* are admitted: *Baeolophus wollweberi wollweberi* (Bonaparte), from central and southern Mexico, and *Baeolophus wollweberi annexus* (Cassin), from northwestern Mexico and the contiguous portion of the southwestern United States. Reasons are given for the recognition of *Geothlypis trichas brachidactyla* (Swainson), from the northeastern United States and southeastern Canada; *Vermivora celata orestera* Oberholser, from the western United States, southwestern Canada, central and northern Mexico; *Molothrus ater artemisiae* Grinnell, from the western United States and western Canada; and *Loxia curvirostra bendirei* Ridgway, from the mountains of the western United States; all of which have been discredited by recent authors. The recent attempted elimination of *Dendroica caerulescens cairnsi* on the ground of untenability is shown to be wrong, and its characters as a recognizable race are given. The British form of *Passer domesticus*, with which the introduced English sparrows of the United States are found to be identical, recently described as *Passer hostilis*, is shown to be but a subspecies of the continental European bird, and should therefore be called *Passer domesticus hostilis*. H. C. O.

ORNITHOLOGY.—*Three remarkable new species of birds from Santo Domingo.* J. H. RILEY, Smithsonian Misc. Coll. **66**: No. 15. Pp. 1–2. December 1, 1916.

That the possibilities of the avifauna of the island of Santo Domingo are not yet exhausted is emphasized by the three remarkable new birds recently discovered there by Dr. W. L. Abbott. The first is an owl, *Asio noctipetens*, of a genus hitherto unrepresented on the island. Another is *Brachyspiza antillarum*, belonging to a genus not before detected in any of the West Indies. Still more remarkable is a new white-winged crossbill, *Loxia megaplaga*, of another genus hitherto unknown from the West Indies. Strangely enough, this new *Loxia* is much more closely allied to *Loxia bifasciata* of northern Europe than to *Loxia leucoptera* of North America. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Generic names applied to birds during the years 1906 to 1915, inclusive, with additions and corrections to Waterhouse's "Index Generum Avium."* CHARLES W. RICHMOND. Proc. U. S. Nat. Mus. **53**: 565–636. August 16, 1917.

This is, as its title indicates, a summary of the generic names proposed during the decade which has elapsed since the publication of Dr. Richmond's last similar list, including other names previously omitted or overlooked. A list of the errors in the Index Generum Avium of Waterhouse is first given, together with lists of all the Linnæan genera and a list of the genera published in Bonaparte's papers in the Ateneo Italiano, May and August, 1854. The main part of this paper is an alphabetical list of 607 generic names, together with authority, original citation, type and manner of determination, and indication of the family to which it belongs. Many changes in current names and other nomenclatural notes are added in footnotes. The following new generic names are introduced: *Tychaedon* Richmond, for *Aedonopsis* Sharpe, preoccupied; and *Amoromyza* Richmond, for *Merops samoensis* Hombron and Jacquinot. A catalogue of the 607 generic names of the alphabetical list, arranged under families, is also added.

HARRY C. OBERHOLSER.

ORNITHOLOGY.—*The birds of the Anamba Islands.* HARRY C. OBERHOLSER. Bull. U. S. Nat. Mus. **98**. Pp. v+75, pls. 1–2. 1917.

The Anamba Islands lie in the South China Sea between the Natuna Islands and the Malay Peninsula. They comprise about 20 principal islands, with possibly 200 more islets and rocks, spread over a geo-

graphical area some 55 by 65 miles in extent. Dr. W. L. Abbott was, in 1899 and 1900, the first ornithological collector to visit these islands, and he made a collection of 212 specimens, representing 44 species and subspecies, of which 21 were new. These, together with other observations made by Dr. Abbott, bring the number of birds known from these islands up to 66. This number will doubtless be greatly increased by future explorations, though the Anamba group does not seem to be so rich in bird life as the Natuna Islands, which lie nearer Borneo. In only one case, so far as known, are there two subspecies of the same species on different islands in this group. Of the birds now known from the Anambas, 11 are migrants from the north, and do not breed on the islands. Fifteen subspecies are peculiar to the Anamba Islands, and six other subspecies occur outside of the group only on some other islands of the South China Sea. The remaining 24 Anamba birds belong to more or less wide-ranging species. Taken as a whole, the Anamba Islands are faunally most closely allied to the Malay Peninsula; less so, but about equally to Sumatra and Borneo; still less to Java; and only slightly to Indo-China. Among the most interesting of the new forms discovered by Dr. Abbott in the Anamba Islands might be mentioned those of the genera *Muscadivores*, *Collocalia*, *Artamides*, *Cyornis*, *Hypothymis*, *Kittacincla*, *Lamprocorax*, and *Dissemurus*.

H. C. O.

ORNITHOLOGY.—*The birds of Bawean Island, Java Sea.* HARRY C. OBERHOLSER. Proc. U. S. Nat. Mus. **52**: 183–198. Feb. 8, 1917.

Bawean Island is mountainous, with an area of approximately 100 square miles, from which some 18 species of birds had been recorded prior to Dr. W. L. Abbott's visit from November 19 to 28, 1907. His collection of 35 specimens of birds is of much interest, since 7 of the 15 species represented prove to belong to undescribed forms, most of them, so far as known, confined to this island; and since it adds 8 species to the list, making a total of 26 now known from here. The avifauna of Bawean Island as a whole is most closely allied to that of Java, but it has also a marked Bornean infusion. Among the most interesting new forms discovered by Dr. Abbott are a new hawk of the genus *Spilornis*, very different from the Bornean *Spilornis pallidus* and much nearer the Sumatran bird, *Spilornis bassus*; a new species of *Strix*, very different in coloration from *Strix orientalis* and *Strix ocellata*, the characters of both of which it somewhat curiously combines; and a new form of *Malacocincla abbotti*. A series of *Microtarsus baweanus*, collected by

Dr. Abbott, proves this bird to be only a subspecies of *Microtarsus chalcocephalus* of Java. H. C. O.

ORNITHOLOGY.—*A review of the genus Pediocetes in Colorado.* F. C. LINCOLN. Proc. Biol. Soc. Wash. **30**: 83–86, pl. 1. May 23, 1917.

The sharp-tailed grouse inhabiting the eastern foothills of the Rocky Mountains in Colorado is found to differ subspecifically from *Pediocetes phasianellus columbianus* of Colorado west of the Continental Divide and also from *Pediocetes phasianellus campestris* of the plains in the northeastern part of this State, and is named *Pediocetes phasianellus jamesi.* HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Additions to the Haitian avifauna.* PAUL BARTSCH. Proc. Biol. Soc. Wash. **30**: 131–132. July 27, 1917.

The form of the South American *Porzana flaviventris* occurring on the island of Haiti proves to be a recognizable subspecies, and is named *Porzana flaviventris hendersoni*, after Mr. John B. Henderson. The Haitian golden warbler is distinguished from *Dendroica petechia petechia* of Jamaica and reinstated as a subspecies under the name *Dendroica petechia albicollis* (Gmelin). Eleven other species, mostly water-birds and shore birds, are listed as additions to the avifauna of the island of Santo Domingo. This list includes *Chaetura pelagica*, an entirely unexpected record for April. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*The Porto Rican grasshopper sparrow.* JAMES L. PETERS. Proc. Biol. Soc. Wash. **30**: 95–96. May 23, 1917.

The resident form of the grasshopper sparrow found in Porto Rico proves to be separable from both the Curaçao and Santo Domingo forms, and is named *Ammodramus savannarum borinquensis.*

HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Preliminary diagnoses of apparently new birds from Colombia and Bolivia.* W. E. CLYDE TODD. Proc. Biol. Soc. Wash. **30**: 3–6. January 22, 1917.

Seven new species here described are *Phoenicothraupis rubiginosus*, from Colombia; *Attila caniceps*, from Colombia, and *Attila neoxenus*, from Bolivia, two remarkable new birds of this tropical genus; *Xiphocolaptes obsoletus*, from Bolivia; *Celeus innotatus*, from Colombia; *Pyrrhura subandina*, from Colombia; and *Eupsychortyx decoratus*, from Colombia. Ten subspecies from Colombia and Bolivia are also described, among the most interesting of them *Bubo virginianus elutus*, from Colombia. HARRY C. OBERHOLSER.

ORNITHOLOGY.—*New genera, species, and subspecies of South American birds.* W. E. CLYDE TODD. Proc. Biol. Soc. Wash. **30:** 127–130. July 27, 1917.

Two new genera are *Idiospiza*, proposed for *Linaria inornata* Lafresnaye; and *Poecilurus*, for *Synallaxis candaei* Lafresnaye. A new species is *Poecilurus atrigularis*, from Colombia. Nine new subspecies from Venezuela, Colombia, and Panama are also described.

HARRY C. OBERHOLSER.

ORNITHOLOGY.—*Mutanda ornithologica. I.* HARRY C. OBERHOLSER. Proc. Biol. Soc. Wash. **30:** 75–76. March 31, 1917.

During the past several years the writer has incidentally noted a number of necessary changes in the current scientific names of birds. This article is the first of a series designed to set forth these changes. In the present installment the following changes are made, chiefly on the ground of preoccupation: *Nettion torquatum* (Vieillot) becomes *Nettion leucophrys* (Vieillot); *Chloephaga magellanica* (Gmelin) becomes *Chloephaga leucoptera* (Gmelin); *Cerchneis gracilis* (Lesson) is renamed *Cerchneis araea* Oberholser; *Cerchneis alopex desertícola* Reichenow is renamed *Cerchneis alopex eremica* Oberholser; and the fossil *Rallus intermedius* Milne-Edwards is called *Rallus adelus* Oberholser, nom. nov. H. C. O.

ORNITHOLOGY.—*Washington region [winter of 1916–1917].* HARRY C. OBERHOLSER. Bird-Lore **19:** 153. 1917.

This paper is the first of a series designed to present current reports on the birds about Washington, D. C. This installment treats of the winter birds of 1916–1917 up to the month of March. That winter proved notable for the presence of several interesting northern visitors, including *Loxia leucoptera*, *Loxia curvirostra minor*, *Spinus pinus pinus*, and *Olor columbianus*. An individual of *Polioptila caerulea caerulea*, seen, January 1 (erroneously recorded as January 2), and one *Corthylio calendula calendula*, noted, January 20, also are worthy of special mention. During the beginning of the spring migration two species appeared much earlier than ever previously noted: *Seirus motacilla* on March 17, and *Nemospiza henslowii henslowii* on April 1. H. C. O.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES

The 120th meeting of the Academy was held in the Assembly Room of the Cosmos Club the evening of January 31, 1918; called to order at 8.30 by President BRIGGS. The amendments to the By-Laws presented at the Annual Meeting, January 8, 1918 (see this JOURNAL of February 4, 1918), were adopted, on the recommendation of the Board of Managers.

Professor FRIDTJOF NANSEN, of the University of Kristiania, Norway, at present Minister Plenipotentiary of Norway on a special mission to the United States, delivered a lecture on *Changes in oceanic and atmospheric temperatures and their relation to changes in the sun's activity.*

The lecturer gave a very comprehensive review, illustrated with lantern slides, of the subject matter of a book recently published by him jointly with Professor BJÖRN HELAND HANSEN, of the Museum of Bergen, under the title, *Temperatur-Schwankungen des Nordatlantischen Ozeans und in der Atmosphäre. Einleitende Studien über die Ursachen der klimatologischen Schwankungen.*[1]

The primary aim of the research was to find the relations existing between oceanic and atmospheric temperatures. The surface temperature of the water in various parts of the North Atlantic at the coldest time of the year formed the foundation of the first study. When the region covered by the data is divided into approximately equal areas, the temperature curves of these areas are found to be parallel. It is evident from the form of the curves that these changes of temperature taken as a whole are not due to changes in the water-masses transported. A relation does appear, however, between these changes and the prevailing direction of the wind, as deduced from atmospheric pressure gradients. Where the wind turns south of (i.e. is directed south of) its average direction over a period of years, the temperature of the water is lower than the average for the same period, and vice versa. A similar parallelism between wind direction and water temperature appears along the coast of Norway; the effect near the coast is based upon the direction of the wind with respect to the land, as well as upon the season of the year. The air temperature variations on land appear earlier than the variations in water temperature.

Certain periodicities appear in all the curves of oceanic and atmospheric temperatures, but they vary in type. At the same time a relation also appears between these curves and curves of sun-spot activity

[1] Videnskapsselskapets Skrifter, I Mat.-Naturv. Klasse, 1916, No. 9. Kristiania, 1917.

and magnetic elements. The 11-year period is prominent. An oceanic type and a continental (Eurasian) type can be distinguished. The latter follows the sun-spot curve directly, whereas the former type follows the sun spots inversely. There is also a third and very remarkable type in which the curve changes more or less suddenly from direct to inverse. This sudden inversion is brought out in many curves, comparing stations in different parts of the earth, and the inversion occurs in very many cases at about the year 1896.

When the temperature curves for different months of the year are compared with the sun-spot curves, these three types of agreement again appear in very puzzling and unexpected combinations.

In addition to oceanic and atmospheric temperatures, other meteorological elements (air pressure, wind velocity, rainfall, cloudiness, mean daily temperature-amplitude) show a relation to the sun spots, sun prominences, and magnetic variations, and show not only the 11-year period but also shorter periods of two, three, and five and one-half years.

The fluctuations of the temperature at the earth's surface do not follow directly the variations in the energy received from the sun as determined by the measurements of Abbot and Fowle. The daily and yearly temperature-amplitudes are believed to furnish sufficient refutation of hypotheses based on supposed variations in the absorbing and reflecting power of the atmosphere, as well as of Humphreys' hypotheses as to formation of ozone or effects of volcanic dust. Blandford's hypothesis of the effect of increased evaporation in lowering continental temperatures at sun-spot maxima is also not supported by the facts of tropical land and ocean stations.

The mistake of most authors when they have discussed the causes of temperature changes has been that they took for granted that the average temperature at the earth's surface was directly dependent on solar radiation, and would give a direct indication of heat received. They have not considered sufficiently the fact that a very great proportion of the sun's radiation is absorbed by the higher layers of our atmosphere and that the distribution of heat in the atmosphere is of the greatest importance for the temperatures at the earth's surface. They seem very often to have forgotten that the variations in the sun's activity, and in the so-called "solar constant," and also in the sun's electric radiation, may primarily influence the higher layers of the atmosphere, thus indirectly guiding the distribution of atmospheric pressure and the circulation not only of these higher layers but also of the lower parts of the atmosphere. In this manner the temperature of the higher latitudes may be influenced more than that of the tropics, where the conditions are so stable.

The variation in *pressure gradient* seems much more closely related to the temperature of land stations than is the variation in air pressure itself. For instance, the Colombo-Hyderabad gradient runs parallel to the temperature in the Himalayas but opposite to the temperature at Batavia, while Bombay forms an example of those strange reversals occurring about 1896. The Iceland-Azores gradient has exactly oppo-

site effects in Norway and in mid-Atlantic. An increase of air circulation may thus have opposite effects in different regions. The sun spots and magnetic elements sometimes oppose and sometimes agree with the variations in pressure gradients.

Various periodicities appear in the sun spots as well as in the terrestrial phenomena. In the sun spots there is an 8-month period corresponding with the conjunction or opposition of the planets Venus and Jupiter with the sun. This same period occurs in the North Atlantic gradient, and was found by Krogness in the magnetic declination at Kristiania. There are also periods of six and twelve months in the magnetic elements, due to the position of the earth. The combination of these 6, 8, and 12-month periods gives a 2-year period for the magnetic and meteorological elements on the earth. But in the fluctuations of the sun spots a similar period of two years is also discovered, and especially noticeable are indications of minima every second year. Before 1896 there is an agreement between the 2-year minima of temperature at certain stations and the corresponding sun-spot minima, but the agreement is remarkable in that the greatest depressions in the sun-spot curve coincide with the smallest depressions in the temperature curve; this relation ceased about 1896, hence the peculiar inversion already referred to.

Other periodicities have been recognized. A 32-33-month period at Batavia may be a combination of the 2-year period already referred to and a 3.7-year period suspected by Lockyer. Secular changes of relatively long period (35 years and over 100 years) also are probable. The researches of Clayton have recognized correlations in daily temperature and pressure fluctuations at various stations over the earth and the fluctuations in the daily heat radiation of the sun as measured by Abbot and Fowle, the same three types appearing in these meteorological variations as have been noted in the long-time variations. Krogness recognizes 14-day and 27-day periods in magnetic storms, as well as in air-pressure gradients, wind, and temperature, in northern Norway.

To summarize the results of these investigations: In different groups of areas on the earth the meteorological elements (temperature, barometric pressure, rainfall, etc.) fluctuate or pulsate, so to speak, in time with one another, while in other groups of areas the fluctuations or pulsations are exactly inverted, and finally, some areas show transition stages between the two. The result of all this is a very complicated picture of the meteorological fluctuations. But by means of appropriate analyses we see that from this complicated and apparently chaotic set of fluctuations there arises a clear picture of the very intimate relation between all these variations and the variations in the sun's activity. We have seen that even changes of very short duration in the sun's radiation (of heat as well as electricity) are distinctly repeated in our meteorological conditions and in the surface temperature of the ocean. The effects of the solar variations are probably transferred by means of variations produced in the distribution of pressure

in our atmosphere. Changes in solar radiation probably first affect the higher layers of our atmosphere, and thus create an unrest which in turn is transmitted to the lower strata near the earth's surface.

Such dynamic changes will produce different effects in different regions of the earth. But by thorough and complete analyses of the great meteorological material now at hand it may be possible to find the general rules. This will be an important step forward toward understanding the laws ruling our atmosphere.

For this purpose it will also be of the greatest importance to have the wonderful researches of Abbot and Fowle continued with the greatest possible efficiency. These investigations of the sun's radiation of heat, which they have been carrying on for a long series of years at Washington, Mount Wilson, Mount Whitney, and in Algeria, have given us the remarkable revelation that our sun is a variable star, the most important discovery that has been made in this field in many years. (*Author's abstract.*)

WILLIAM R. MAXON, *Recording Secretary.*

BIOLOGICAL SOCIETY OF WASHINGTON

The 577th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, January 12, 1918; called to order at 8.00 p.m. by President ROSE; 38 persons present.

On recommendation of the Council the following were elected to membership: E. A. CHAPIN, F. P. METCALF, CHARLES E. CHAMBLISS.

President ROSE announced the death on October 29, 1917, of Miss KATHERINE M. RABER, a former member of the Society.

President ROSE announced the membership of the Publication Committee as C. W. RICHMOND, J. H. RILEY, N. DEARBORN, and W. L. MCATEE; of the Committee on Communications as WILLIAM PALMER, ALEX. WETMORE, R. E. COKER, L. O. HOWARD, and A. S. HITCHCOCK.

The Recording Secretary read a letter from the Washington Academy of Sciences in which subscriptions to the Journal of that Society were solicited on the part of members of the affiliated societies, and in which the aims and character of the Journal were set forth.

Dr. L. O. HOWARD introduced Prof. STEPHEN A. FORBES, of the University of Illinois, as a visitor to the Society who was invited by the President to take part in the discussions.

Under the heading brief notes, General T. E. WILCOX presented a note read by the Secretary on the inability of camels to swim.

A. S. HITCHCOCK outlined the plans formulated by a gathering of botanists during the scientific meetings recently held in Pittsburgh for the establishment of an abstract journal on the subject of botany.

The regular program consisted of three communications as follows:

N. E. MCINDOO: *The senses of insects*, illustrated by charts. Three types of olfactory organs were discussed. (1) The lyriform organs are found on all the appendages of spiders. (2) The olfactory pores found on the appendages of insects were divided into simple and compound

organs; the former being a single sense cell whose peripheral end pierces the integument, and the latter being a group of sense cells whose peripheral ends pierce a common plate; the compound organs are found only on the antennae of a certain coleopterous larva. (3) The antennal organs discussed are the pore plates, pegs, pit pegs, and end pegs; each of these organs is innervated, but the nerve does not come in direct contact with the external air as it does in the lyriform organs and olfactory pores.

Bees recognize one another chiefly by the odors they emit; in a colony there are a queen odor, drone odor, family odor, individual odor, and a hive odor. The hive odor is the most important one, because without it a colony of bees could not exist. These odors are produced by a special scent-producing organ.

The tactile sense of bees is very acute, and these insects can discriminate between certain foods better than people, although they have no sense of taste; this is accomplished by means of the highly developed olfactory sense after the bees have eaten a little of the foods.

The paper was discussed by Dr. L. O. HOWARD and ALEX. WETMORE.

ELEANOR C. ALLEN: *Wax models of fleshy fungi*, with an exhibit of several models. Miss Allen said she had been engaged for the past four years in making models of this sort for the Milwaukee Public Museum. She illustrated her talk by models of four species of mushrooms, each being represented by a group of several individuals arranged as in their living condition. She described the processes incident to the making of the finished groups. Living specimens growing in woods or fields are found and before picking sketches of the group and complete notes in regard to color and habitat are made. Then plaster models of the various individuals are made. In the laboratory, using these models, wax mushrooms are cast and the details of these are worked out by careful modeling, coloring, and the addition of various materials to give a natural appearance of texture. Habitat material such as grass, moss, stumps, etc., are gathered and chemically treated. Backgrounds, natural to individual species, are prepared from these materials and upon these the wax facsimiles are arranged. Miss Allen showed photographs of the numerous groups which she has made and which are now installed in the Milwaukee Public Museum.

Miss Allen not being a member of the Society was introduced by President ROSE. Her communication was discussed by the chair, and by Messrs. F. V. COLVILLE and A. S. HITCHCOCK.

C. B. DOYLE: *Some agricultural and botanical features of Haiti*, illustrated by lantern slides. In Haiti there is very little left to represent the original forest covering. The primitive milpa system of agriculture is used and the natives live in scattered families or small groups. Most of the food plants are of American origin, butit is the introduced species that have become of the greatest importance to the natives. There are only a few large plantations on the island, the bulk of the crops of the three principal exports (coffee, cacao, and cotton) being produced on the small native farms. Many different kinds of

fine fruits are abundant, but several species prominent in other parts of tropical America, such as the papaya, sapote, sapodilla, and pineapple, are absent or little used. Among the root crops that are commonly grown are sweet potatoes, yams, yautias, and cassava, and more recently white potatoes are being successfuly produced in the cool mountain districts southeast of Port au Prince. In comparison with other tropical countries, conditions appear favorable for crop production in Haiti, if a more effective organization of agriculture can be established together with a better means of marketing the products.

The paper was discussed by Major E. A. GOLDMAN, Dr. L. O. HOWARD, O. F. COOK, A. S. HITCHCOCK, and the chair.

M. W. LYON, JR., *Recording Secretary.*

BOTANICAL SOCIETY OF WASHINGTON

The 125th regular meeting of the Society was held at the Cosmos Club, Thursday, January 3, 1918. There were 65 members and 8 guests present. The following persons were elected to membership: A. A. HANSEN, LEONARD W. KEPHART, H. E. ALLANSON, F. P. METCALF, NATHAN MENDERSON, and T. RALPH ROBINSON. The following scientific program was given:

C. V. PIPER: *The botany and economics of the tribe Phaseoleae.* The word bean traces back philologically to *Vicia faba* known as the horse bean, broad bean, Windsor bean, etc. In present-day usage the word bean is most commonly used for the common or kidney bean *Phaseolus vulgaris*. Botanists in general restrict the term *bean* to the botanical tribe Phaseoleae, but the original bean *Vicia faba* belongs to the tribe Viciae. By extension the word bean has also been applied to seeds in other families, as the castor bean, cacao bean, vanilla bean, etc. On the other hand some of the Phaseoleae are commonly known as peas; for example, pigeon pea and cowpea.

For the purpose of this discussion the term bean is restricted to the botanical tribe Phaseoleae. In this tribe Engler and Prantl recognized forty-seven genera, and Bentham and Hooker fifty. In recent years one additional undoubtedly distinct genus has been described and many botanists subdivide some of the older genera. Thus from Phaseolus have been segregated Dyslobium and Strophostyles and perhaps other natural genera still remain to be separated from the Phaseolus complex. Engler and Prantl divide the tribe Phaseoleae into six subtribes, of which the most important is the Phaseolinae. Of the eight to twelve genera in this tribe all but one or two are economic and seven are important as sources of human food.

All of the edible beans are of very ancient agriculture and most of them have not been found, or at least identified, as wild plants. The exceptions which are known as wild are the cowpea, the horse bean, the soy bean, the lima bean, the moth bean, and the Niger bean.

Most of the beans used for human food are prone to create digestive disturbances, in strong contrast with the seeds of the pea tribe, but

very little is known of the substances in beans which cause these troubles.

The speaker discussed briefly the botanical characters of the more important genera. Detailed data were given concerning the species that are of economic importance in the United States. Particular attention was called to the tremendous increase and relative importance of the velvet bean and of the soy bean.

W. J. MORSE: *Morphological characters and food value of soy-bean varieties.* The soy bean is native of southeastern Asia and has been cultivated as a food crop by the Chinese for more than 5000 years. In extent of uses and value it is the most important legume grown in Asiatic countries. The plant is found growing in its wild form in southern China and on the southern islands of Japan.

The number of varieties cultivated in the Orient is very extensive and during the past ten years the Department of Agriculture has brought in through the Office of Foreign Seed and Plant Introduction nearly 1000 introductions, nearly all of which were distinct sorts. Very seldom is the same sort received twice unless from the same locality. In China and Japan the varieties are distinguished by color, shape, size, and use of the seed, and, to a slight extent, by the maturity. Certain sorts are favored for making bean cheese, others for bean sprouts, some for soy sauce, and still others for the production of oil and meal. In America, varieties are classified according to color, size, and shape of seed, maturity and habit of plant, and color of pubescence and flowers. Analyses made of all varieties introduced thus far show a range of from 12 to 24 per cent oil and from 30 to 46 per cent protein. The Department of Agriculture is doing considerable work in the selection of high oil-bearing varieties and also those with a high percentage of protein for food purposes. Investigations as to starch content indicate varieties having a total absence of starch to a few having perhaps about 3 per cent. In most varieties examined, the starch is found around the hilum, while in one instance a small quantity was found scattered throughout the cotyledons.

In Oriental countries the soy bean is utilized largely for food, being elaborated into a great variety of productions such as soy sauce, vegetable cheeses (fresh, dried, fermented, and smoked), vegetable milk, and bean sprouts. All of these products are rich in protein and furnish, with rice, a well-balanced diet to the people of these countries. In Europe and America soy-bean flour or meal has been used to a small extent for many years as a special food for persons requiring a food of low starch diet. During the last two or three years the dried beans are assuming a place on the American market and are used the same as the field or navy bean. The green beans, about three-quarters to full grown, are finding favor as a green vegetable, being utilized like the lima or butter bean.

As an oil seed, the soy bean has taken an important place in the world's commerce and has become an important competitor of other vegetable oils. Hundreds of thousands of tons of beans are being

crushed for oil and meal in Asia, America, and European countries. The oil is used quite extensively in the manufacture of food stuffs such as butter and lard substitutes.

The soy bean, with its products, oil and meal, present great possibilities in supplementing our ordinary food products during the present emergency, and once introduced on the market will give a highly nutritious food at very low cost. Extensive areas in the United States are suited to the production of soy beans. Although the acreage of the crop the past season is about five times that of five years ago, it should, and no doubt will, assume an important place among the farm crops of the United States.

CHARLES THOM: *Fermented soy-bean products.* Some preliminary experiments have been made to determine the conditions of making and ripening the Chinese soy cheeses.

The presence of a protein allied to the casein of mammalian milk makes possible the manufacture of these cheeses. The basis of these is the so-called Tofu or Dofu; it has various names. This is a soft curd made by the coagulation of the soy-bean milk with calcium sulphate, raw salt, or by acid milk or whey. As it appears in the market, it contains about 83 to 88 per cent water, 7 to 11 per cent protein, 4 to 5 per cent fat, and perhaps 0.5 per cent ash. In the fresh form it is comparable to low-grade Neufchatel or cottage cheese which runs about 10 per cent higher in nutritive constituents. The cakes of curd are usually about 2 inches square and 1 inch thick. These little cakes are ripened in cool, very moist rooms, until covered with a deep felt of mold; then packed in jars with excessive amounts of salt and allowed to cure slowly. The concentration of brine is such as to reduce the activity of microorganisms to a minimum. The final cheeses have high flavor, rather strong odor, and too much salt to be consumed in bulk as cheese. They are covered with red sauce and variously combined with other food products before consumption.

J. A. LECLERC: *The composition of the soy bean and its use in bread-making.* The speaker presented the results of the analyses of several hundred samples representing 45 varieties and grown in six different localities. From these results it was shown that soy beans contain on an average 18.6 per cent of fat and about 40 per cent of protein. It was shown that when all these varieties were grown in the six different localities the influence of environment on the protein and fat content was marked. The average protein content of some soy beans grown in one locality was as low as 38 per cent, while those same varieties grown in another locality would contain as much as 42 per cent, indicating definite varietal characteristics. The same conclusions hold for the fat content. In general, soy beans that are high in fat are low in protein, and vice versa. It was also shown how soy beans can be used as a flour substitute. Samples of bread made with 20 per cent soy bean and 80 per cent white flour were exhibited.

H. N. VINALL, *Corresponding Secretary.*

SCIENTIFIC NOTES AND NEWS

The Bureau of Standards has purchased eight acres of land west of Connecticut Avenue and has let contracts for a new engineering laboratory, 175 by 350 feet and four stories in height. The new building and its equipment will cost in the neighborhood of $1,000,000, and will increase the capacity of the Bureau by 50 per cent. The Pittsburgh laboratory of the Bureau, including the work on glass and ceramics, will be transferred to Washington. It is expected that the new building will be occupied during the coming summer.

Mrs. E. H. HARRIMAN has turned over to the Carnegie Institution of Washington the Eugenics Record Office established by her at Cold Spring Harbor, Long Island, New York, in 1910. Included in the gift are 80 acres of land, an office building, a large residence and the valuable records already compiled. Mrs. HARRIMAN also has created an endowment fund yielding an annual income of $12,000 for maintenance of the work.

Mr. FREDERICK WEBB HODGE, since 1910 Ethnologist-in-charge of the Bureau of American Ethnology, Smithsonian Institution, resigned on February 28, to accept a position with the Museum of the American Indian, Heye Foundation, in New York City. Dr. JESSE WALTER FEWKES, ethnologist on the Bureau's staff since 1895, has been appointed chief of the Bureau.

Dr. ROLLIN ARTHUR HARRIS, mathematician and physicist, who had been employed in the Coast and Geodetic Survey for 28 years, died on January 20, at the age of 55. He was a member of the Philosophical Society, and one of the original members of the Academy. His work was concerned principally with the theory of functions as applied to geodesy and cartography, and with problems of tides and cotidal maps.

Dr. J. W. TURRENTINE, of the Bureau of Soils, is now in charge of the experimental kelp-potash plant of the Bureau, at Summerland, California. The plant has been in operation since late August, and is now marketing daily about $300 worth of materials produced incidentally in experimentation. While primarily experimental, it is built and equipped to make possible the obtaining of commercial data. It has a capacity of about 150 tons of raw kelp per day, and its equipment includes a self-propelling harvester; a pier with unloading device and conveyors; rotary kilns and furnaces for drying; retorts for destructive distillation; lixiviator; evaporator and crystallizer; centrifugal dryers; and the necessary incidental equipment. Dr. Turrentine has as his assistants Mr. E. B. SMITH, formerly of the office of Public

Roads, Mr. P. S. SHOAFF, formerly Chief Chemist of the Holly Sugar Corporation, and Dr. G. C. SPENCER, formerly of the Bureau of Chemistry, together with an operating force numbering forty-three.

Prof. C. C. NUTTING, a member of the ACADEMY, is organizing a party of naturalists, composed almost entirely of graduate students and instructors in zoology at the State University of Iowa, to carry on investigations regarding marine fauna in the vicinity of the islands of Barbados and Antigua, British West Indies. The party will sail about April 27 from New York and expects to return about August 1. The time will be divided between the islands of Barbados and Antigua, at both of which places the Colonial Governments have placed adequate quarters for the party. A well-equipped launch with excellent facilities for dredging down to 200 fathoms has been proffered by a Washington friend, who himself will be a member of the party.

In his preliminary trip to Barbados last summer Prof. Nutting found that the natives of these islands are quite expert in diving, and one of them was capable of bringing up specimens from a depth of 10 fathoms. It is the intention to make rather extensive use of native divers to procure specimens down to this depth.

The following persons have become members of the ACADEMY since the last issue of the JOURNAL: Miss FRANCES DENSMORE, Bureau of American Ethnology, Smithsonian Institution; Major WILLIAM MCPHERSON, War Department, 1800 Virginia Avenue; Dr. FRANCIS BRIGGS SILSBEE, Bureau of Standards.

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